# Astrophysical cross sections

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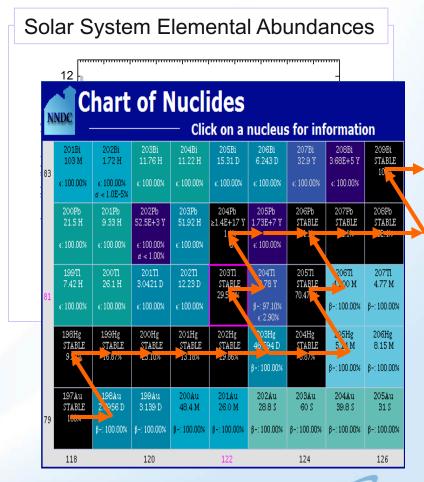


a passion for discovery



## s-process Nucleosynthesis

- Why do we have stable isotopes with different abundances in solar system???
- Why do we have elemental abundances in solar system and stellar atmosphere???
- The very light nuclei (¹H...¹Li) are produced during the Big Bang Nucleosynthesis.
- The light nuclei (<sup>8</sup>Be...<sup>56</sup>Fe) are produced during the explosive burning.
- Valley of Stability nuclei (<sup>56</sup>Fe...<sup>210</sup>Po) are produced by slow neutron capture (sprocess).
- Proton rich nuclei (Z>26) are produced by p-process.
- Neutron-rich nuclei (Z>26) and actinides are produced by rapid neutron capture (rprocess).

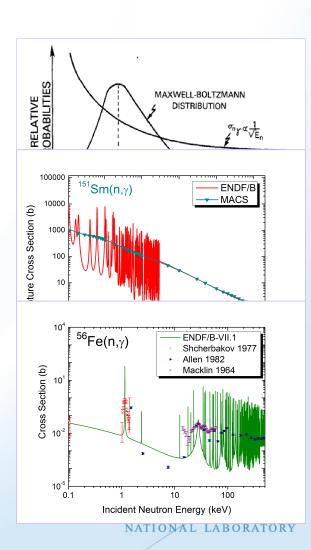


## s-process Cross sections

- Slow neutron capture (s-process) takes place in stars. There is no unique s-process temperature, it depends on a particular star (AGB, Red Giant) and ranges from 8 to 90 keV.
- s-process nucleosynthesis Maxwellian-averaged cross sections (MACS) can be expressed as

$$\sigma^{Maxw} = \frac{2}{\sqrt{\pi}} \frac{(m_1 / (m_1 + m_2))}{(kT)^2} \int_{0}^{\infty} \sigma(E_n) E_n \exp(-\frac{aE_n}{kT}) dE_n$$

where k and T are the Boltzmann constant and temperature of the system, respectively, and E is an energy of relative motion of the neutron with respect to the target. Here  $E_n^L$  is a neutron energy in the laboratory system and  $m_1$  and  $m_2$  are masses of a neutron and target nucleus,  $m_1^L$  are respectively.



## **ENNDF/B-VIII MACS**

- ENDF/B-VIII.β3 and ENDF/B-VIII.β4 library MACS and their uncertainties have been calculated and compared with corresponding values in Karlsruhe
  Astrophysical Database of Nucleosynthesis in Stars (KADoNiS).
- KADoNiS (<u>www.kadonis.org</u>) is stellar nucleosynthesis library that consists of ~85% experimental and ~15% theoretical (NON-SMOKER) cross sections.
- KADoNis values are periodically updated; sometimes new measurements change KADoNiS in dramatic fashion: <sup>19</sup>F(n,γ) from 5.8(12) mb to 3.2(1) mb in versions 0.0 and 0.3, respectively.
- Some of presently-available KADoNiS 0.3 values are impacted by incorrect <sup>197</sup>Au cross sections and will be fixed in 2018.

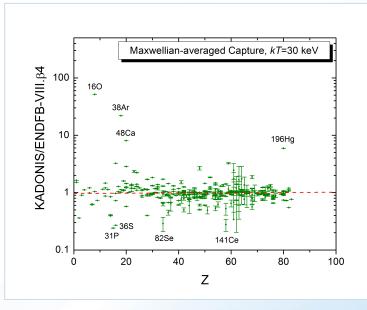
TABLE I: ENDF/B-VII.1 [5], ENDF/B-VIII. $\beta_4$ , KADONIS [3] Maxwellianaveraged cross sections and their ratios at kT=30 keV. Comments: C-calculated from BNL-325 data [6], T-theoretical data in KADONIS.

	TABLE ENDF/ and KA	B-VII.
Material	VII.0	20140
1.H - 1	(barns)	1.55
1-H - 1 1-H - 2 1-H - 3 2-He- 3	1.559E-4 1.980E-6	1.55 1.98
2-He- 3 2-He- 4	2.483E-8	3.29
3-Li- 7	3.290E-5 4.663E-5	
2-He- 3 2-He- 4 3-Li- 6 3-Li- 7 4-Be- 9 5-B - 10 5-B - 11	4.311E-4	9.32 4.31 6.62 1.61
5-B - 11 6-C - 0 6-C - 12 6-C - 13	1.350E-6	6.62 1.61
6-C - 12 6-C - 13	6 696F.5	
7-N - 14 7-N - 15 8-O - 16	6.696E-5 9.175E-6 1.696E-7 4.694E-6	9.17 3.14
1-N - 15 8-O - 16 8-O - 17 8-O - 18 9-F - 19 11-Na - 22 11-Na - 22 11-Na - 23 11-Na - 24 12-Mg - 24 12-Mg - 24 12-Mg - 26 13-AF - 27 14-Si - 29 14-Si - 29 14-Si - 30 15-P - 31 16-S - 32 16-S - 32 16-S - 34 16-S - 36 17-Cl - 37		
9-F - 19 11-Na- 22 11-Na- 23	4 3728 3 80195 3 1.8328 3 5.2901 3 5.2901 3 8.6095 5 3.3077 3 7.7728 3 7.7728 3 7.206 3 2.2077 3 2.207	1.83
12-Mg- 24 12-Mg- 25	3.789E-3 5.280E-3	3.78 5.28 8.61 3.30 3.60
12-Mg- 26 13-AF 27	8.609E-5 3.307E-3	8.61 3.30
14-5i- 28 14-5i- 29	3.607E-3 7.772E-3 4.448F-9	3.60 7.77 4.44
15-P - 31 16-S - 32	7.240E-3 5.660E-3	4.44
16-S - 33 16-S - 34	2.277E-3 2.324E-4	
17-Cl- 35 17-Cl- 37	7.546E-3 2.059E-3	
18-Ar- 36	8.842E-3 1.365E-4	
18-Ar- 40 19-K - 39	2.248E-3 1.850E-2	
19-K - 40 19-K - 41	1.941E-2 3.140E-2	2.031
20-Ca- 40 20-Ca- 42 20-Ca- 43	5.147E-3 1.241E-2 2.520E-2	
1814 K. K 441 142 144 144 144 144 144 144 144 144	2.039E-3 8.842E-3 1.363E-4 2.26E-2 1.941E-2 3.440E-2 5.147E-3 1.241E-2 3.530E-2 7.56E-3 1.080E-4 6.840E-3 2.039E-2 3.307E-27E-853E-3 3.307E-27E-853E-3 3.105E-3 2.573E-2	
20-Ca- 48 21-Sc- 45 22-Ti- 46	1.080E-4 6.840E-2 2.020E-2	2.54
22-Ti- 47 22-Ti- 48	3,307E-2±5,863F-3	4.86 2.65 1.58
22-Ti- 49 22-Ti- 50	1.159E-2 3.105E-3	1.58 3.044
23-V-0 23-V - 50		
24-Cr- 50 24-Cr- 52		7.99
24-Cr- 53 24-Cr- 54	3.142E-2 7.696E-3	
26-Fe- 54 26-Fe- 56	3.102E-2 2.161E-2 1.151E-2	3.28 2.16
26-Fe- 57 26-Fe- 58	2.849E-2 1.974E-2	1.15 2.84
27-Co- 58 27-Co- 58M	5.587 -2 6.442 -2	
28-Ni- 58 28-Ni- 59	3 783E 2 8 545E 3 3 142E 2 7 190E 3 3 10E 2 2 161E 2 1 1974E 2 5 547E 3 4 002E 2 6 963E 2 2 2 856E 3	3.38
28-Ni- 60 28-Ni- 61	2.826E-2 7.179E-2 5.145E-2 2.200E-2 7.150E-2 3.915E-2	2.67
28-Ni- 58 28-Ni- 59 28-Ni- 60 28-Ni- 61 28-Ni- 62 28-Ni- 64 29-Cu- 63 29-Cu- 65	5.145E-2 2.200E-2	
29-Cu- 65	7.150E-2 3.915E-2	

Material	ENDER-VIL1	ENDEVE-VIIL 84	(harro)	ENDE/B-VIL (/ENDE/B-VIIL $\beta_4$	KADONIS/END#B-VIII.8
1-H - 1 1-H - 2 1-H - 3	1.560E-4±5.890E-6 1.980E-6±1.240E-7	1.560E-4 ± 5.840E-6 1.980E-6 ± 1.240E-7	2.540E-4±2.000E-5 3.000E-6±2.000E-7	1.010E+0±8.300E-6 1.000E+0±1.750E-7	1.650E+0±2.080E-5 1.520E+0±2.350E-7
1-H - 3 2-Hc - 3	2.1108-5	2.1108-5	7.600E-6±6.000E-7	1.0008+0	3.6008-1±6.0008-7
2-He- 4 3-Li- 6	32908-5+31808-6	3.2906-5		1.000E+0±3.180E-6	
3-LJ-7 4-Be-7	4.66081-5	4.6600-5	4.200E-5±3.000E-6	1.0008+0	9.010ti-1±3.000ti-6
4-lk-9	9.3208-6±1.8688-6	9.3200-6±1.8600-6	1.0408-5±1.6008-6	1.00000+0±2.6300-6	1.120E+0±2.450E-6
5-B - 10 5-B - 11	43108-4 ± 1.4508-4 66208-5 ± 2.0508-5 1.6208-5 ± 1.2308-6	3.440E-4 6.620E-5 ± 2.050E-5 1.620E-5 ± 3.230E-6		1.250E+0 ± 3.449E-4 1.000E+0 ± 2.900E-5 1.000E+0 ± 4.570E-6	
6-C - 12	1620E-5±1230E-6	1.50E-5 1.230E-6	1 Sept. 5+1 ppgs 2	1.000E+0±4.570E-6	9 8908-1+1 9998-2
6-C-13		1.7406-5	1.540E-5±1.000E-6 2.100E-5±1.000E-6		9.8908-1±1.0008-6 1.2108+0±1.0008-6
7-N - 14 7-N - 15	6.7008-5 9.1008-6+4.9008-6	67008-5 9 1978-6+4 5978-6	4.1008-5±60008-5 <sup>C</sup>	1.0008+0	6.1208-1±6.0008-5
8-O - 16 8-O - 17	9.180E-6±4.590E-6 3.150E-5±3.160E-6 4.700E-6	9.180E-6±4.590E-6 3.640E-5 4.700E-6	5.000E-6±6.000E-7 3.000E-5±4.000E-6	1.000E+0±6.490E-6 N.660E-1±3.160E-6 1.000E+0	6.3208-1±4.6308-6 1.0508+0±4.0008-6
8-O - 18		1.7206-7	8.860E-6±8.000E-8 3.200E-3±1.000E-4		5.160E+1±8.000E-8 7.320E-1±2.070E-4
9-1' - 19 11-Na- 22	43708-3±1.8208-4 8.0208-3 1.8308-3±1.3708-4 3.7908-3±7.1808-4 5.2808-3±1.3108-6	4.370E-3±1.820E-4 8.020E-3		1.000E+0±2.570E-4 1.000E+0±1.999E-4 1.000E+0±1.015E-3 1.000E+0±1.850E-6	
	1830E-3±1.370E-4	8.0208-3 L8308-3 ± 1.3708-4 3.7908-3 ± 7.1808-4 5.2808-3 ± 1.3108-6	2.100E-3 ±2.000E-4 1.300E-3 ±4.000E-4 6.400E-3 ±4.000E-4	1.000E+0±1.939E-4	1.150E+0±2.430E.4 8.710E-1±8.220E.4 1.210E+0±4.000E.4
12-Mg- 24 12-Mg- 25	5290E-3±1.310E-6	5.280E-3 ± 1.310E-6	6.400E-3±4.000E-4	1.000E+0±1.850E-6	1.210E+0±4.000E-4
12-Mg- 26 13-AI- 27	\$610E-5 ± 1.620E-5 \$310E-3 ± 5.610E-4 \$610E-3 ± 8.000E-4	1,610E-5 1,620E-5 1,510E-3 1,610E-4 1,610E-3 1,000E-4	1.20E-4 ±9.000E-6 1.740E-3 ±3.000E-4 1.420E-3 ±1.300E-4	1.000840 ± 2.2908-5 1.000840 ± 7.9368-4 1.000840 ± 1.1318-3 1.000840 ± 1.1818-3 1.000840 ± 2.1498-3	1.46EE+0±1.85EE-5 1.13EE+0±6.36EE-4
14-51-28	3610E-3 ± 8,000E-4	3.610E-3 ± 8.000E-4	1.420E-3±1.300E-4	1.000E+0±1.131E-3	3.9408-1±8.1108-4
14-51-30 15-P - 31	7.7708-3 ± 8.3508-4 4.4508-3 ± 1.5208-3 7.7408-3	7.770E-3 ± 8.350E-4 4.450E-3 ± 1.520E-3 7.343E-3	6.500E-3 ± 6.600E-4 1.820E-3 ± 3.300E-4 1.740E-3 ± 9.000E-5	1.000E+0±2.149E-3 1.000E+0	4.0908-1±1.5608-3
16-5 - 32	5,6608-3	5,6600-3	4.100E-3±2.000E-4	1.0008+0	7.24081-1±2.0008-4
16-5 - 33 16-5 - 34	2.28081-3 2.32081-4	2.2808-3 2.3208-4	4.100E-3 ± 2.000E-4 7.400E-3 ± 1.500E-3 2.260E-4 ± 1.000E-5	1.0008+0 1.0008+0	1.210E40 ± 4.000E.4 1.40E40 ± 1.830E.5 1.13E40 ± 6.360E.4 3.340E.1 ± 1.10E.4 8.470E.1 ± 1.560E.3 4.070E.1 ± 1.560E.3 7.340E.1 ± 2.000E.4 3.25EE.4 ± 1.500E.3 9.730E.1 ± 1.000E.5 2.200E.1 ± 1.400E.5
14.8.36	6.3308.4	CTARK A	1.710E-4±1.400E-5	1.000840	2.7008-1±1.4008-5
17-C1-38 17-C1-37	7.540E-3 2.040E-3	7.540E-3 2.040E-3	1.710E-4±1.400E-5 9.690E-3±2.100E-4 2.120E-3±7.000E-5	1.0008+0 1.0008+0	2.7008-1±1.4008-5 1.2808-0±2.1008-4 1.0408-0±7.0008-5
18-Ar- 36	8.840E-3	8.8406-3	re recent to day above to T	1.0008+0	1.020E+0±1.500E-3
18-Ar-38 18-Ar-40	1.3708-4 2.2508-3	1.3708-4 2.2508-3	3.000E-3±3.000E-4 <sup>T</sup> 2.540E-3±1.000E-4	1.0008+0 1.0008+0	2.200E+1±3.000E-4 1.130E+0±1.000E-4
19-K - 39	1.0608-2	1.0606-2		1.0008+0	1.120E+0±4.000E-4
19-K - 40 19-K - 41	1.9408-2 2.0008-2+1.0608-16	1.9408-2 2.0008-2+1.0608-16	3.100E-2±7.000E-3 <sup>T</sup> 2.200E-2±7.000E-4	1.000E+0 1.000E+0 ± 1.490E-16	1.600E+0±7.000E-3 1.000E+0±7.000E-4
20-Ca- 40 20-Ca- 42	5.1506-3 1.2406-2	9.970E-3 1.240E-2	2.2008-2±7.0008-4 5.7308-3±3.4008-4 1.5608-2±2.0008-3	5.160E-1 1.000E+0	1.080E+0±7.000E-4 5.750E-1±3.400E-4 1.260E+0±2.000E-3
20-Ca- 43	3.5308-2 7.7408-3	3.5306-2 7.7406-3	5.100E-2±6.000E-3	1.000840	1.450E+0±6000E-3
20-Ca- 43 20-Ca- 44 20-Ca- 46	7.74081-3 1.86081-3	7.7408-3 1.8608-3	5.100E-2±6.000E-3 9.400E-3±1.300E-3 5.300E-3±5.000E-4	1.000E+0 1.000E+0	1.450E+0±6,000E-3 1.210E+0±1.500E-3 2.850E+0±5.000E-4
20-Ca- 48 21-5p- 45	1.0808-4 6.8408-2	1.080E-4 6.940E-2	8.700E-4±9.000E-5	1.000E+0 1.000E+0	8.0500:40 ± 9.0000:-5 1.0100:40 ± 5.0000:-3 1.0500:40 ± 3.2000:-3
22-TI-46	2.550E-2±1.210E-7	2.550E-2±1.210E-7	2.690E-2±3.200E-3	1.000E+0±1.710E-7	1.050E+0±3.200E-3
22-TI-47 22-TI-48	4.8708-2±1.4508-3 2.6608-2±7.0408-9	4.870E-2 ± 1.450E-3 2.660E-2 ± 7.040E-9	3.180E-2±5.100E-3	1.000E+0±2.049E-3 1.000E+0±9.96E-9	1.320E+0±7.840E-3 1.200E+0±5.100E-3
22-TI-49 22-TI-50	1.580E-2±2.96E-6 3.040E-3±8.050E-12	2.550E-2±1.210E-7 4.870E-2±1.2450E-3 2.660E-2±7.040E-9 1.580E-2±2.960E-6 3.040E-3±8.050E-12	\$.00E-3±5.000E-4 8.70E-4±5.000E-3 6.90E-2±5.000E-3 6.44E-2±7.700E-3 1.10E-2±5.100E-3 2.210E-2±2.100E-3 1.600E-3±6.000E-4	1.000840±17108-7 1.000840±2.0498-3 1.000840±2.9608-9 1.000840±4.1908-6 1.000840±1.1408-11	1.320E+0 ±7.840E-3 1.200E+0 ± 5.100E-3 1.400E+0 ± 2.100E-3 1.180E+0 ± 4.000E-4
23-V-0	1	±			
23-V - 50 21-V - 51	2.1308-2	2.1306-2	5.0008-2±9.0008-2 <sup>T</sup>	1.0008+0	2.350E+0±9.000E-2 1.190E+0±4.000E-3
23-V - 51 24-Cr- 50 24-Cr- 52	3.8308-2	3.2106-2 3.8306-2 7.9908-3±27108-4	1.800E-2±4.000E-3 4.900E-2±1.300E-2 8.800E-3±2.300E-3	1.000E+0 1.000E+0±3.831E-4	1.190E+0±4.000E-3 1.290E+0±1.300E-2 1.100E+0±2.320E-3
24-Cz-53	2.60081-2	2.6008-2	5.NOOE-2±1.000E-2	1.0008+0	2.230E+0±1.000E-2
24-Cr- 54 25-Mp- 55	4.7808-3 3.2808-2+2.6708-3	4.780E-3 3.280E-2+2.670E-3	5.8008-2±1.0008-2 6.7008-3±1.6008-3 1.9608-2±3.0008-3 2.9608-2±1.3008-3 1.1708-2±5.0008-4 4.0008-2±4.0008-3	1.000E+0 1.000E+0+3.770E-3	2.230E40 ± 1.000E-2 1.400E40 ± 1.600E-3 1.210E40 ± 4.010E-3 1.090E40 ± 1.300E-3 8.380E-1±5.000E-4 1.110E40 ± 4.000E-3
26-76-54 26-76-56	\$2806-2±2.6706-3 21606-2±2.6806-3 1.1506-2±1.1806-3 2.8506-2±4.6806-3	2.7206-2 1.4006-2	2.960E-2±1.300E-3	1.000E40±3.770E-3 7.960E-1±2.678E-3 8.240E-1±1.180E-3 7.910E-1±4.604E-3	L090E+0±1300E-3
26-16-57	2850E-2±4.60E-3	3,6006-2	4.000E-2±4.000E-3	7.910E-1±4.604E-3	1.110E+0±4.000E-3
26-Rt- 58 27-Co- 58 27-Co- 58M	1.9708-2 2.0208-1 6.4408-2	1.510E-2 2.110E-1± 6.660E-2±	1.350E-2±7.000E-4	1.310E+0 2.60E-1	K.9608-1±7.0008-4
27-Co- 58M	6.44081-2	64408-2±		1.0008+0	a constant a more a
27-Co- 59 28-Ni- 58	3.390E-2±2.790E-3	3.430E-2 3.390E-2±2780E-3	1.960E-2±2.700E-3 1.870E-2±1.500E-3	1.0000040 ± 3.9250-3	1.160E+0±2.700E-3 1.140E+0±3.160E-3
23-Ni- 59	6.9608-2 2.6908-2+1.5908-3	5.100E-2 2.690E-2±1.590E-3	8.7008-2±1.4008-2 <sup>T</sup>	1.370E+0 1.000E+0±2.253E-3	1.710E+0±1.400E-2
23-Ni- 60 23-Ni- 61 23-Ni- 62	9.03081-2	9.3106-2	2.990E-2 ± 7.000E-4 8.200E-2 ± 8.000E-3 2.230E-2 ± 1.600E-3	9.7108-1	1.120E+0±1.740E-3 8.810E-1±8.000E-3 9.360E-1±1.600E-3
28-Ni- 64	2.38081-2 2.01081-2	2.380ti-2 2.000ti-2	8.000E-3±7.000E-4	1.000E+0 1.000E+0	3.990t-1±7.000t-4
29-Cu- 63 29-Cu- 65	7.150ti-2 3.920ti-2	5.9306-2 3.3806-2	8.000E-3 ± 7.000E-4 5.50E-2 ± 2.200E-3 2.90E-2 ± 1.300E-3	1.2108+0 1.1608+0	3.9908-1 ± 7.0008-4 9.3808-1 ± 2.2008-3 8.8208-1 ± 1.3008-3
30-Zn-64	6.1008-2	± 61006-2		1,0000+0	
30-Zn- 65	6.100ti-2 1.680ti-1	6.1008-2 1.6808-1	5.900E-2±5.000E-3 1.620E-1±2.700E-2 <sup>T</sup>	1.0008+0	9.670E-1±5.000E-3 9.660E-1±2.700E-2
30-Zn- 66	3.6408-2 1.1608-1	3,6408-2	1.500E-2±3.000E-3 1.500E-1±1.500E-2 1.920E-2±2.400E-3	1.000E+0 1.000E+0	9.610E-1±3.000E-3
30-Zn- 66 30-Zn- 67 30-Zn- 68	2.06081-2	2.0908-2	1.920E-2 ± 2.400E-3	1.0008+0	9.6108-1±3.0008-3 1.3208-0±1.5008-2 9.2508-1±2.4008-3
30.2n. 20	1.1708-2	1.1706-2	$\substack{2.1508.2 \pm 2.0008.3 \\ 1.3908.1 \pm 6.0008.3 \\ 1.2308.1 \pm 8.0008.3}$	1.0008+0	1.840E+0±2.000E-3 1.170E+0±4.000E-3 1.010E+0±8.000E-3
31-Cla- 69 31-Cla- 71	1.1908-1 1.2208-1	1.1908-1 1.2208-1	1.230E-1 ±8.000E-3	1.0008+0 1.0008+0	1.010E+0±8,000E-3
32-Oc- 70 32-Oc- 72	8.92081-2 5.30081-2	8.9206-2 5.3006-2	7 aven 2 de com a T	1.000E+0 1.000E+0	9.870E-1±5.000E-3 1.380E+0±7.000E-3
32-Oc- 73	2.1000-1	2.1006-1	2.4308-1±4.7008-2 <sup>T</sup>	1.0008+0	1.160E+0±4.70E-2
32-Oc-76 32-Oc-76	4.5400-2 1.7000-2	4.540E-2 1.700E-2	2.430E-1±4.700E-2 <sup>T</sup> 3.760E-2±3.900E-3 2.150E-2±1.800E-3	1.000E+0 1.000E+0	1.160E+0±4.70E-2 8.280E-1±3.900E-3 1.270E+0±1.80E-3
33.4x.73		7.900E-1	A CONTRACTOR OF THE PARTY OF TH		- Announce Landers
33-Ap-74 33-Ap-75	1.360E+0 4.500E-1	1.29081+0 4.5008-1	3.620E-1±1.900E-2	1.060E+0 1.000E+0	KD408-1±1.9008-2
34-5c-74 34-5c-76	2.08081-1 9.58081-2	2.0808-1 9.5808-2	2.710E-1±1.500E-2 1.640E-1±8.000E-3	1.000E+0 1.000E+0	1.300E+0±1.50E-2 1.710E+0±8.000E-3
34-Sc-77	4.4508-1	4.4506-1	4.1808-1±7.1008-2 <sup>T</sup>	1.0008+0	9.4008-1±7.1008-2 6.6308-1±9.6008-3
34-Sc-78	9.0708-2	9.0706-2	6.010E-2 ± 9.600E-3	1.0008+0	6.630E-1±9.600E-3
34-5c-79 34-5c-80	4.150ti-1 3.930ti-2	4.1506-1 3.9306-2	2.630E-1±4.600E-2 <sup>T</sup> 4.200E-2±3.000E-3	1.000E+0 1.000E+0	6.3408-1±4.6008-2 1.0708-0±3.0008-3
34-Sc- 1/2	3.1108-2	3.1106-2	$\substack{9.0008.3 \pm 8.0008.2 T \\ 6.2208.1 \pm 3.4008.2}$	1.0006+0	2.8908-1±8.0008-2 9.0608-1±3.4008-2
35-Br-79 35-Br-81 36-Kr-78	6.87081-1 2.29081-1	6.870E-1 2.290E-1	6.220E-1±3.400E-2 2.390E-1±7.000E-3	1.000E+0 1.000E+0	9.0608-1±3.4008-2 1.0508-0±7.0008-3
	4.7108-1 2.9508-1	3.1906-1 2.9506-1	2.390E-1 ±7.000E-3 3.210E-1 ±2.600E-2 2.670E-1 ±1.400E-2	1.490E+0 1.000E+0	1.050E+0±7.000E-3 1.010E+0±2.600E-2 9.070E-1±1.400E-2
36-Kr-78	1.0008-1	1.0306-1	9.000E-2±6.000E-3 2.400E-1±1.500E-2 3.000E-2±4.000E-3	1.0008+0	9.07608-1±1.4008-2 8.7608-1±6.0008-3 9.1008-1±1.5008-2 1.440840±4.0008-3
36-Kr-N0 36-Kr-N2		2.670E-1	2.430E-1±1.500E-2	1.000E+0 1.000E+0	9.100E-1±1.500E-2
36-Kr-103	2.6708-1	2.6400-2	3.NOOE-2+4.000M-3		
36-Kr-N2 36-Kr-N2 36-Kr-N3 36-Kr-N4	2.6400-2 1.2200-1	2.640E-2 1.220E-1	5.500E-2±4.500E-2 <sup>T</sup>	1.0006+0	4.490E-1±4.500E-2
36-Kr-82 36-Kr-83 36-Kr-83	2.6708-1 2.6408-2	2.6408-2	3.500E-2±4.500E-2 <sup>T</sup> 3.500E-2±4.500E-2 <sup>T</sup> 3.400E-3±3.000E-4 2.340E-1±7.000E-3		4.4908-1±4.5008-2 6.7108-1±3.0008-4 8.3108-1±7.0008-3

# ENNDF/B-VIII.β4 MACS

- There are noticeable differences between KADoNiS and ENDF/B-VIII.b4 libraries for light and medium nuclei.
- 1,2H and <sup>3</sup>He experience significant deviations due to differences between center of mass and lab system cross section values.
- Other deficiencies could be separated into three groups:
  - <sup>31</sup>P, <sup>36</sup>S and <sup>196</sup>Hg KADONIS values are based on a single recent measurement.
  - Due to lack of experimental data theoretical values were adopted for <sup>38</sup>Ar, <sup>82</sup>Se, <sup>141</sup>Ce.
  - Deficiencies in <sup>16</sup>O and <sup>48</sup>Ca originate from the old or insignificant for integral tests ENDF evaluations and coverage problems in EXFOR database.



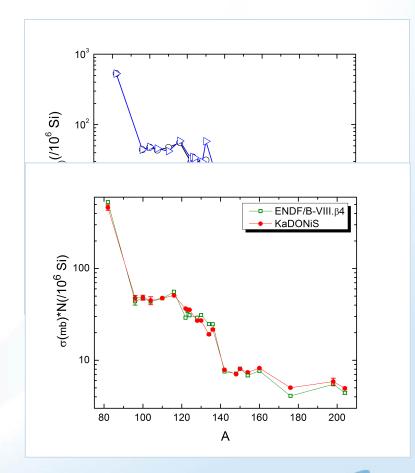


# **Stellar Nucleosynthesis**

In s-process nucleosynthesis, the product of neutron-capture cross section ( at 30 keV in mb) times solar system abundances (relative to Si = 10<sup>6</sup>) as a function of atomic mass should be constant for sprocess only equilibrium nuclei

$$\sigma_A N_A = \sigma_{A-1} N_{A-1} = const$$

- Visual inspection of the figures indicates two local equilibrium and ledge-precipice break at A~138 for the ENDF libraries fit.
- Strong astrophysical potential of the ENDF/B-VIII.β4 library





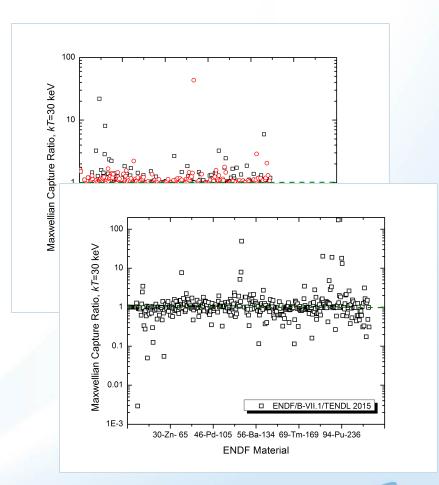
#### TENDL 2015 vs. ENDF/B-VII.1

- In September 2016 A. Sonzogni has suggested to evaluate both libraries using Maxwellian-averaged cross sections in KADoNiS.
- A few comments on TENDL 2015:
  - Overall neutron library size: 14.8 GB
  - Doppler-broadened neutron library, 0.1%: 237 GB
  - Processing time on Windows PC: 1-1.5 days
- More on TENDL 2015: 2809 materials. It is missing <sup>129,130,131,135</sup>I that exist in ENDF/B-VII.1.
- TENDL has astrophysical adjustments, while ENDF is not.
- ENDF/B-VII.1 is definitely better for Sr, Te, Sm and Hg. No difference for major actinides. In other cases TENDI 2015 is often better.
- TENDL 2015 is better matched with theoretical values in KADONIS (NON-SMOKER calculations).



## TENDL 2015 vs. ENDF/B-VII.1

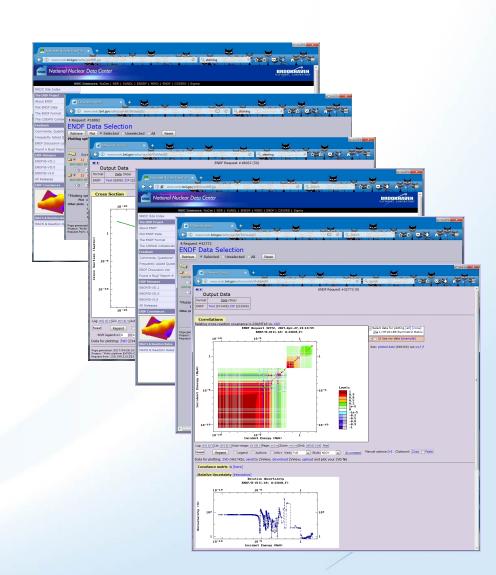
- NNDC style calculations of MACS were produced; INTER results listed in TENDL 2015 were ignored as not very reliable.
- Comparison with KADoNiS.
- Comparison of two libraries Maxwellian-averaged cross sections, kT=30 keV.
- Current values could be helpful Identification potential deficiencies in both libraries.
- The good news that we have time to improve ENDF/B and KADoNiS is not always perfect.





## ENDF/B-VIII.β4 Web Interface

- ENDF/B-VIII.β4 is available at the NNDC website:
  - http://www.nndc.bnl.gov/endf
- Powerful tool for ENDF/B-VIII.β4 quality assurance.
- Example of 56Fe(n,γ) retrieval for ENDF/B-VII.1 and ENDF/B-VIII.β4.
- Example of 238U(n,F) covariance retrieval for ENDF/B-VIII.β4.
- Collaborative effort with Viktor Zerkin (IAEA).



#### **Conclusions & Outlook**

- There is a very strong astrophysical potential of ENDF/B-VIII.β4 library.
- Several deficiencies have been identified in ENDF/B-VIII.β3 and ENDF/B-VIII.β4 releases.
- ENDF/B-VIII developers should not be intimidated by KADoNiS or TENDL cross sections. It is important to produce its own product.
- Do we need calculations of RI, Westcott factors, <sup>252</sup>Cf and thermal cross sections using ENDF/B-VIII library?
- Do we need any comparison with TENDL?
- Any missing in EXFOR nuclear astrophysics data sets could be processed at NNDC if necessary.

